Rapid Imaging of Interwell Fluid Saturations Using Seismic and Multiphase Production Data

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RESEARCH OBJECTIVES

Seismic imaging is a very powerful tool for obtaining high-resolution views of the subsurface. The current goal of this research project is to use seismic and fluid flow observations to estimate reservoir flow properties such as porosity and permeabilities.

APPROACH

This year, we have developed a method that maps estimates of reservoir pressure change, obtained from geophysical observations, into interwell permeability variations. This technique allows us to obtain high-resolution images of reservoir permeability in a reliable fashion. The method derives from the fact that if we fix the pressure in the equation for fluid flow, we have a linear first-order partial differential equation for permeability. Thus, we use the time-lapse data to estimate pressure variations in the reservoir. We then substitute these pressures in the flow equation and solve for permeability.

ACCOMPLISHMENTS

We have applied the imaging technique to a set of crosswell seismic and electromagnetic data gathered at the Lost Hills oil field. Time-lapse crosswell data were collected before and after the injection of CO_2. The data were first mapped into water and CO_2 saturation changes and pressure changes between the wells (Figure 1a). Based upon these changes, we then inferred reservoir permeability variations (Figure 1b).

SIGNIFICANCE OF FINDINGS

The results are significant because they enable us to estimate permeability directly from geophysical observations. Note specifically that reservoir simulation is not required in this approach. Furthermore, the inverse problem for permeability is linear in nature, and consequently the solution is more robust and less sensitive to an initial reservoir model. Also, we can estimate permeability in regions that have undergone pressure changes. Thus, we can estimate permeability for portions of the reservoir that have not yet been produced.

RELATED PUBLICATIONS

Vasco, D.W., K. Karasaki, and K. Kishida, A coupled inversion of pressure and surface displacement. Water Resour. Res., 37, 3071–3089, 2001.

Vasco, D.W., A. Datta-Gupta, R. Behrens, P Condon, and J. Rickett, J., 2003. Seismic imaging of reservoir flow properties: Time-lapse amplitude changes. Geophysics 2003 (submitted).

Vasco, D.W., Seismic imaging of reservoir flow properties: Time-lapse pressure changes. Geophysics, 2003 (submitted).

ACKNOWLEDGMENTS

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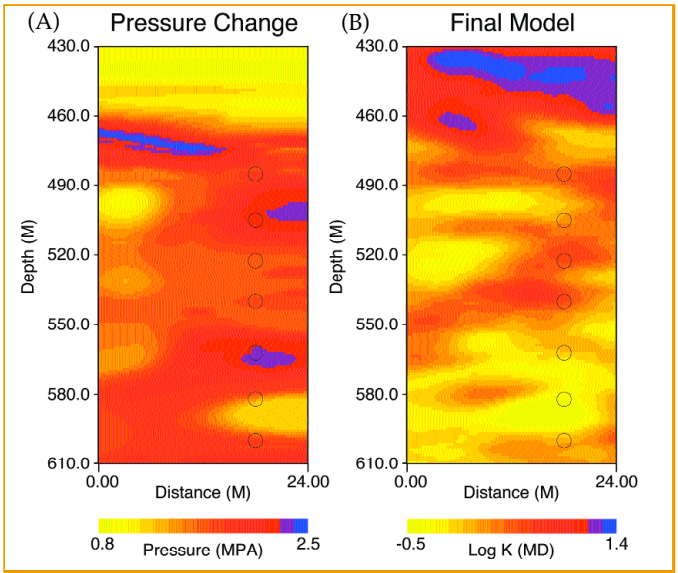

Figure 1. (A) Pore pressure changes due to the injection of CO_2. (B) Estimates of reservoir permeabilities in the interwell region.